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Abstract

Connectivity and isolation problems have become a source of policy interest in all European countries, largely as a result of the goal of the completion of the internal market. Against this background, the present paper aims to analyze the future position of the Aegean passenger shipping system. This system will likely face major changes, caused by technological and political-economic factors. The driving forces and the subsequent implications of these future developments for the Aegean short sea shipping sector will be investigated. The analytical framework is based on a blend of forecasting modelling and scenario experiments for the Aegean transport system. Consequences of international political-economic changes as well as new transport (de)regulations (such as hub-and-spokes systems or market contestability) are traced in the paper with a view on identifying feasible futures for the Aegean maritime transport sector.

1. Towards an Open Network Economy

In the past decade the spatial-industrial organization of modern economies tends increasingly towards a **multi-actor and multi-modal network configuration,** in which **free access and competition** are becoming dominant features (see Cuadrado-Roura et al. 1994, Nijkamp 1994 and Porter 1989). In recent policy documents of the European Union it is taken for granted that the development of the European continent is shaped through a complex interplay of a networked physical space (composed of an open multi-regional system) and a multi-layer socio-economic structure (featuring open access and free competition), witness also the plans for the T.E.N. (Trans-European Networks) system. The drive towards a network economy - as a catalyst for accelerated economic growth - has been favoured by drastic changes in telecommunication and information technology (see Capello 1994), including the use of advanced logistics and electronic data transmission.

The emphasis on network infrastructure in Europe is also caused by the strategic argument that one of the primary objectives of the European Union is to achieve and strengthen social and economic cohesion within the Union. Consequently, isolated areas have to be connected to more centrally located and intermediate regions or nodal points in the European network. It is expected that through improved connectivity the locational potential and advantages of isolated areas will improve. It should be noticed in this context however, that network connectivity offers a window of locational opportunities - in the form of necessary development conditions -, but that no guarantee does exist for an accelerated regional growth (see for a thorough study on this topic Bruinsma 1994). Nevertheless, it is important that new initiatives for. a higher performance of the European network be made.

At the same time the awareness is growing that the European network system is still a **fragmented** system, which by far does not maximize its potential benefits. This has been convincingly demonstrated in recent discussions on missing links and missing networks in Europe (see Nijkamp and Vleugel 1994). Apparently, many countries have still an individualistic behaviour based on self-interest. As a result, we observe many impediments to a maximization of the economic synergy (and value added) of European networks. Apart from financial and environmental constraints, still many other bottlenecks do exist, such as protectionist behaviour, cabotage restrictions, protection of national carriers, lack of international network cooperation, and lack of a multi-modal transport strategy from a European perspective.

The consequence of the above scene is clear: many regions in Europe are not well connected and even much more isolated than necessary. Unnecessary network constraints are not in the interest of people for whom the regulations have been designed!

It is also evident from recent policy discussions that network policy should not only address the issue of **(de)regulation** of the **demand** side, but also the **morphology** (and hence **design)** of a network at the **supply** side. The main emphasis should therefore be on a maximization of socio-economic benefits through **network connectivity.** Connectivity does not only have a physical meaning, but also an immaterial meaning (e.g., access to informal information or linkage to organizational networks). This is closely linked to the notion of **externalities** of networks (see Cape110 1994).

Generally speaking, networks tend to become the vehicles through which competition (and related value added) is favoured, and may hence be conceived of as critical success factors in an open economy. This clearly has implications for network policy, which should focus in particular on: **cohesiveness, openness, complementary logistics, private initiatives, network standardisation** and **deregulation.** Only under these conditions one may expect that networks will fulfil their catalytic role in a competitive environment. This holds at the overall European level, but also at specific levels, such as metropolitan economies, island economies etc. Based on the previous observations, networks can be typified according to:

- the structure of the transport market (free competition, regulated market etc.)
- the type of mode (road, rail, waterways, air etc.)
- the geographical coverage (from local to global)
- the quality of service (including scale and scope), and the tariff system
- the sophistication of transportation technology (e.g., logistic platforms, telematics, information systems)
- the structure of the network (e.g., hierarchy, hub and spokes etc.)
- the territorial and modal policy competence on networks
- the barriers to a full performance of networks (e.g., regulations, conflict of competence etc.)
- the integration with telecommunication (EDI, e.g.).

In the next section we will specify the above considerations with a view on our scenario case study for the Greek islands.

2. Network Policy Analysis: A Blend of Forecasting Models and Scenario Experiments for the Greek Passenger Shipping System

Isolation is not only a matter of **physical morphology** of a spatial system, but is also determined by **market conditions** (e.g., degree of competition) and **policy regulations** (e.g., fare structures or access conditions) in a transport system. Thus the topological features of a network (e.g., origin-destination links) are dependent on physical geography, market forces and policies. **Technological progress** in transport systems may play a catalytic role in changing the degree of isolation (or peripherality), as it is able to influence physical bottlenecks or impediments to spatial accessibility, while at the same time it has an impact on market operations and policy initiatives.

The evolution of network use rests on an interplay between **demand** and **supply.** The demand side is associated with spatial mobility needs which have to be fulfilled at reasonable conditions (time, fares, reliability, frequency, comfort, flexibility, safety etc.). Historically, the transport sector has - for equity reasons - always been an economic activity featuring much government interventions (including subsidisation). Only in the past decade, a strong tendency towards deregulation has emerged, starting in the U.S. airline sector, but gradually spreading to all transport sectors. With some delay, this is also happening in Europe, where deregulation is also accompanied by decentralisation and privatisation (see Nijkamp and Blaas 1993).

The central variable that reflects isolation of an area or of a group of people is **distance.** From a geographical perspective, isolation of a certain area can then be expressed as physical distance to the geographical centre. The degree of socio-economic isolation of a group can be considered as the difference between their income per capita and the overall average income (see Biehl, 1986). From a mobility perspective, the degree of isolation of a specific region can be seen as the difference between the socio-economic capability of inhabitants of that region to travel to other regions and the capability of inhabitants of other regions to reach the first region. From a spatial access point of view the degree of isolation can be described as the extra travel time or cost and inconveniences that are attached to travelling to or from a certain region, in comparison to other regions.

Over the last few years, a trend in European transport planning can be witnessed, namely a shift in emphasis from demand to supply side policy. This has led to a shift in emphasis from mobility to access. This implies that transport planning is now focused more on passenger inconveniences, in both financial terms and in terms of extra travel time and other obstacles. The European transport policy will definitely have consequences for all network operations: road transport, railways, waterways, airlines, and public transport. The main idea is that a (re)regulation of the transport sector will improve efficiency and will hence also favour the more isolated regions in Europe.

A prominent example of such an isolated area is formed by the Greek island system, which includes a large number of dispersed islands of different size categories and degree of accessibility. An additional disadvantage of the Aegean archipelago in comparison to other European peripheral regions is the fact that the Aegean islands (14.7 % of the Greek population in 1981 (Statistical Yearbook of Greece 1989)) are scattered over an area that is in size almost equal to the size of the Greek mainland. This makes access an even more difficult issue. Greek passenger shipping is considered necessary for both communication and integration as well as development of the Greek island and coastal economy, so as to minimize the isolation effect, especially during the winter months. The Aegean is one of the poorest regions in both Greece and the EU. In the eight inhabited North Aegean islands the GNP per capita is 35% of the EU average, while the 42 South Aegean islands show a GNP per capita amounting to 46.5% of the EU average, a difference likely stemming from the difference in tourist attractiveness between the two areas.

The traditional network system here was the shipping system, which was fairly well developed, but which is increasingly suffering from its low speed which places many islands at a vulnerable competitive edge. Competition in the shipping sector is also severely restricted through protectionist tariff regulations and cabotage prohibitions. In the new EU policy regulations for the transport sector, these unnecessary rules would have to be removed, but for time being the Greek island system has - by way of exception - been placed in a privileged protectionist system, so that socio-economic inefficiencies will temporarily continue to exist. EU institutions have until now not shown any interest of awareness regarding the need to include ferry transport as an issue in transport infrastructure policy. The interisland transport does not belong to the general integrated transport market policy of the E.C. However, ferry links function as basic elements providing access in many countries in the maritime periphery of Europe (see Jacobsen and Kristiansen 1992).

Nevertheless, the Greek shipping system is bound to go through a phase of economic, logistic and organizational restructuring, partly as a result of technological development, partly as a result of market conditions (e.g., hub-and-spokes configurations), partly as a result of EU regulations and partly as a result of changes in external policy conditions (notably the relations with Turkey). In our analysis we will mainly focus now on the shipping system in the Aegean Sea, as the geographical position of the islands in the Aegean makes them particularly suitable for network operations and analysis.

First, we shall discuss the **Aegean degree of interinsular connectivity.** Theoretically, the degree of interinsular connectivity can be described as the extent to which islands are linked to other islands in space and time. It is determined by topological aspects (availability or existence of links between nodes, resulting in morphology or network configuration), correspondence (existence of through connections and waiting times between different connections), frequency of lines, fluctuation of the frequencies of links over time (per day, week, month or year), and reliability of service (depending e.g. on climate/weather conditions (seagoing capabilities), on political conditions (labour strikes and shutdowns depending on degree of unionization) and on compliance with the pre-advertised timetable). Compliance refers to the performance of the company itself (punctuality) and to the presence of sufficient capacity on each ferry departure. Travel time is determined by both speed and connectivity. Speed and connectivity both have a positive relation to travel time.

Now, in order to describe the elements of Aegean interinsular connectivity, we turn to the function of the Aegean passenger shipping system. Its function is to play a strategic role in strengthening social and economic cohesion (and thus to overcome isolation) within the EU through connecting the various peripheral (from both a Greek and an EU perspective) Aegean islands with one another, with the Greek mainland and with other EU regions. The Aegean shipping network finds itself on the edge of the transport and communication network planned within the national framework, and is thus somewhat peripheral from a Greek perspective. In addition, the Greek transport network is also located on the south western periphery of the EU. So, the Aegean has a **double** (or **super)peripheral** feature. This results in inadequate and unsuitable links with non-peripheral regions. The current network configuration shows a clear radial pattern, the hub being the port of Piraeus. In recent years, also Rafina has gained significance as the second biggest passenger port of the Attica region. Frequencies are fairly high on most routes to and from Piraeus, but low on the majority of other routes. A more liberal policy towards granting concessions for new lines has been followed by the Ministry of Merchant Marine, over the last few years. Also faster types of vessels have been introduced, leading to more hub and spokes elements in the network. Furthermore, a strong barrier element at the eastern edge of the network can be noticed, caused by the still tense political relations with Turkey. This means that many connections with Turkey have low frequencies (or are not served at all) and are suffering from high taxes. The unreliability of the Aegean shipping network is largely caused by

Greek labour union strikes and by frequent bad weather conditions during winter time. Barriers to optimal transfer possibilities are created by insufficient road access and parking facilities in and around seaports and lack of computerization, especially in the central port of Piraeus, which also has a serious telecommunication deficiency (see Psaraftis and Papanikolaou 1992). Opportunities for improving the shipping system might be offered through such features as Computerized Reservation Systems and brand loyalty programs, which are already extensively used in air transport.

Connectivity for transit transport is reasonable for many trips via Piraeus, but certainly not for other routes. In island ports, transit opportunities are often very bad, especially during the low season. Very few islands have regular links with one another. Most Aegean islands have a shipping connection frequency of once (or less) a week. During the winter this can even be less due to bad weather conditions and/or lack of interest from the part of shipping companies. The seasonal fluctuation is one of the most important characteristics of Aegean transport and probably the one causing most concern. The existence of peaks destroys comfort, limits safety and causes delays, while during off-peak periods continuity of service is at stake.

Seasonality is defined as the fluctuation of demand and to a lesser extent of supply over time. Use of maritime transport is traditionally high during the summer and low during the winter, due to fluctuations in tourism. Accordingly, the physical structure of the network also varies significantly between summer and winter as does the quality of service. Regardless of season, the quality of service also varies between short routes (only basic facilities) and more distant routes (more luxurious accommodation). An additional disadvantage of seasonality is the inevitable waste of capacity caused by an imbalanced spatial spread of demand, since huge flows on certain routes can be witnessed in only one direction at certain times. This implies empty vessels on the return segment of the route.

An analysis of seasonality over the period 19851989 (based on Goulielmos and Lekakos 1992) shows that 50 percent of demand is spread over 25 percent of the time, namely the third quarter. An extra 15 percent of total annual traffic takes place in June (8.3 % of the year). So, 65 percent of passenger demand takes place in 33.3 percent of the year, resulting in a peak demand during one third of the year of nearly double the monthly average and nearly four times the demand during the winter. A perfect supply (no under- or overcapacity) would imply that frequency times capacity per vessel are in the high season four times larger than in winter time. Considering only the two busiest months of the high season, capacity must then even be more than four times the average winter capacity. Since the government has ordered a certain minimum frequency during the low season, the largest part of capacity reduction must then be realized through operating smaller vessels.

In the early 70's the first ferry service to the Greek islands started to operate. The ferry mode of operation has steadily grown ever since. Due to the introduction of larger and larger ferries, "this mode . . . constitutes now an integral and the strongest component of the system. Compared to other European countries (Northern Europe, Italy, Channel) their average speed is low" (see Psaraftis and Papanikolaou 1992). But their speed is gradually increasing. On a number of routes hydrofoils are increasingly being used. Around 1000 ships are currently operated in

Greece. The average age of the fleet rose from 14.5 years in 1981 to 21 years in 1990. The average ferry carries about 700 passengers, the maximum capacity being 2.300 passengers and an average speed of about 16 knots (see Psaraftis and Papanikolaou 1992).

Various entry barriers have been created to protect the Greek passenger shipping market from competition, both domestic and foreign. These barriers require **strong regulation,** which occurs in the form of required licenses, certificates of approval and other conditions, such as flying the Greek flag, Greek ownership, maximum age of 20 years, legal obligation to provide service also during winter months and so on. Hence, the operational freedom of the shipping companies is limited. Lines that are not profitable, but that must be served for equity reasons (e.g. to isolated islands), are subsidized. The Greek government decision-making process turns out to have become significantly bureaucratic. “Decisions are long delayed because of paper shuffling between Ministries in Athens.” (Lloyd’s List International, 1991). Also, market transparency is flawed, which deteriorates the **perception** of network connectivity by passengers. Applying current marketing theories to networks would suggest that not **real** connectivity is valued by the passengers, but its perceptions. This perception improves when cooperation is established between shipping enterprises to improve communication towards the public with respect to prices, schedules, through connections etc.

Furthermore, the operation of the Greek market mechanism is also limited by restrictions imposed on the functioning of the price mechanism. An Advisory Committee on **prices** was set up in 1992 and organised hearings in which the users of the Aegean network did not participate. It appears that “fares are not affected either by demand or by cost or . . . by competition” (see Goulielmos and Lekakos 1992). It is also a plausible assumption that fares are **fixed** higher than those of the competitive equilibrium but slightly lower than the monopoly level. This pricing policy does obviously not consider any explicit welfare calculations (see Goulielmos and Lekakos 1992). It yields a high producer surplus and also renders higher cost to the consumer. The consequent lack of incentives to reduce costs results in economic inefficiencies. Since competition until now cannot take place in terms of prices, other features gain significance in competition, such as the same (or close) time of departure for the same destinations, time of arrival, duration of a trip and level of comfort (see Goulielmos and Lekakos 1992).

The main aim of our analysis is now to identify the **driving forces** of changes in and the consequences for the future development of the Aegean shipping system. This requires first of all a network model depicting all forces at work and their expected consequences. According to a systems view on the transport field, the main factors that determine the future development of the network can be subdivided into four (interrelated) themes, namely a subdivision into the **internal** ‘behavioural’ mechanism, the **external** environment (both the **socioeconomic** and **technological** context) and the **control system** (made up by policy measures) (see Nijkamp et al. 1990). Consequently, the factors that we consider to be the most interesting and dominant ones are now turned from a conceptual level into an operational level. They will prompt significant change to the network and dramatically alter the pattern of passenger flows.

The first dominant political factor is the **European unification** process. It is expected that economic growth in the region will be stimulated by EU policies, since Greece and the Aegean in particular are peripheral regions. As a result of this unification process, the **cabotage** restrictions are foreseen to be lifted in the year 2004. From then on, competition from non-Greek shipping companies in Aegean waters will be allowed. This leads to better standards of service, lower costs and thus lower prices.

The second political factor is the state of **Turkish-Greek relations and an eventual Turkish E&membership.** In 1994 these relations are still operating on a low level, resulting in the imposition of high transport barriers and thus in high transport costs between the two countries. If political relations improve, economic relations are also likely to ameliorate. Additionally, numerous forms of travel restrictions will be relieved. This may then lead to an increase in Greek-Turkish traffic. More and cheaper shipping connections can then be established, inducing a higher overall network efficiency and increasing attractivity for passengers. The centre of gravity of the network will probably gradually move eastward.

The last policy factor is the proposal for a **design of one or more (bimodal) hub-and-spokes systems by Greek network operators** in order to improve attractivity of the network. This type of networks has a large degree of connection density and accordingly a shorter average travel time. This is beneficial to both consumers and transport companies. The companies are then able to offer a more attractive product and operate more efficiently.

Finally, a dominant external factor is accentuated by **technological innovation** in the past decade(s). It plays an important role, since the introduction and application of new technology has resulted in faster, cheaper, more comfortable, more silent and less polluting ships. These more attractive features will have a positive impact on the demand for shipping transport. Figure 1 presents a schematic overview of the principal factors.

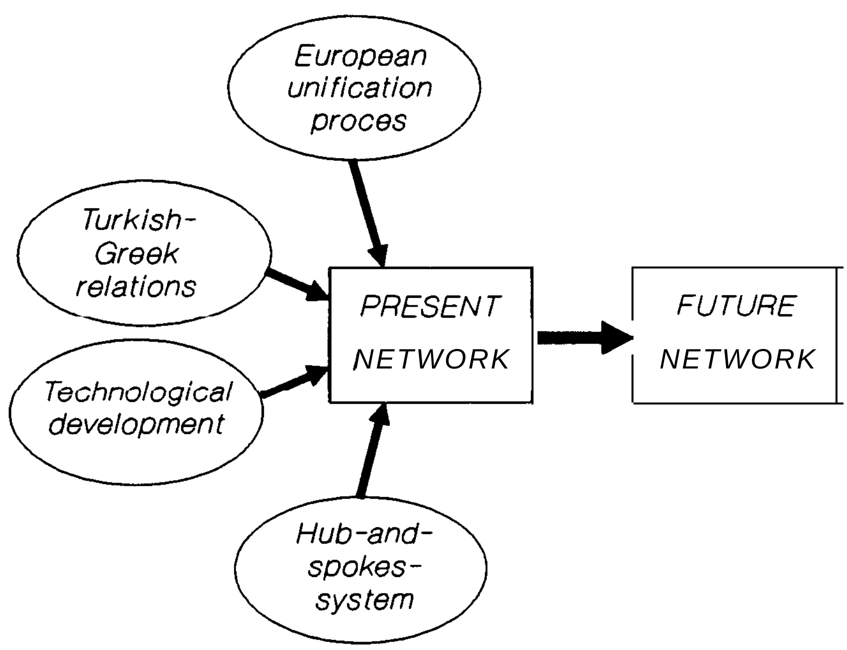


Figure 1: Principal factors influencing the Aegean passenger shipping network

After the completion of the framework depicting the driving forces at work, a systematic assessment of long-range uncertainties has to be made, based on plausible or reasonable future scenarios for the area under study. Thus we have to create an analytically feasible blend between predictive modelling and meaningful scenario developments. The differences between forecasting models and scenarios are illustrated in Table 1.

Forecasting models	Scenarios
❑ Focus on quantified variables ❑ More emphasis on detail ❑ Results determined by status quo ❑ From present to future ❑ Deterministic analysis ❑ Closed future ❑ Statistical-econometric tests ❑ From simple to complex ❑ From quantitative to qualitative	❑ Focus on qualitative pictures ❑ More emphasis on trends ❑ Results determined by future images ❑ From future to present ❑ Creative thinking ❑ Open future ❑ Plausible reasoning ❑ From complex to simple ❑ From qualitative to quantitative

Table 1: Differences between forecasting and scenario analysis

In our operational framework we will integrate scenario experiments with network modelling for the Aegean short sea shipping system. This means that first a comprehensive network model has to be designed and calibrated, while next scenario experiments are superimposed on this modelling system. For more background on short sea shipping, see ECMT 1993, Wijnolst et al. 1993 and Gwilliam et al. 1993.

We will characterize the demand side of the transport market in Section 3 and the supply side in Section 4. Then, Section 5 will discuss the design of a (deterministic) simulation model, coined ZKH[1], which models the evolution of the passenger shipping system. The model enables the use of quantitative impact methods. The input of the model consists of scenarios describing the way characteristics change over time or in what way they depend on other characteristics in each season. The output of the model is formed by the future values of the characteristics. The meaning of the model is to modify in a clear way the development of basic characteristics and/or the relation between the characteristics and examine the effect these changes have on other characteristics of the transport market in the Aegean. Because of the close correspondence between these characteristics and the model variables, the characteristics may be conceived of the variables of the model. The various assumptions of the model will be given throughout the various sections. All assumptions made here were needed and have a background effect. In Hiemstra en Zwier(1994) a Decision Support System is

[1] ZKH stands for Zwier, Ko and Hiemstra. Zwier is the inventor, Ko symbolises all outside support and Hiemstra is the co-author.

presented as a software tool to work with the model*. In Section 6 we will define four scenarios which include the principal factors and discuss some analyses and results, corresponding to several scenarios. Finally, in Section 7 we will present some conclusions.

3. The Demand Side of the Transport Market

The demand side of the Aegean maritime transport system is described by means of a network. A network consists of nodes and edges. The nodes in the network of passenger shipping can either be a port on the main area or an island. A main area in our study is an area on the continent or a special island, which is selected for special reasons. We selected four main areas:
1. The Greater municipality of Athens (Athens Area), because it contains the most important port for transport to and from the Aegean, namely Piraeus.
2. The island of Paros in the Cyclades, because Paros may function as a potential future hub island.
3. The bigger municipal area of Izmir (Izmir Area), as it is important to analyze the consequences of vanishing political barriers with Turkey.
4. The Turkish South-Westcoast (South West Turkey), because this area may also be used in analyzing the socio-political barriers between the nations.

The difference between the two Turkish nodes is that Izmir Area may be used more for transport between Athens and Turkey, while South-West Turkey has a significant touristic impact.

The other nodes are the islands in the Aegean. Figure 2 gives an overview of these islands, which we have selected according to their size. The smallest island is Arki, with a surface of 6 square kilometres. All islands (expressed in minors) and main areas (expressed in capitals) are represented by a point in a two-dimensional space. The nil point of this geographical map is 36.0 degrees Northern latitude and 23.2 degrees Eastern latitude.

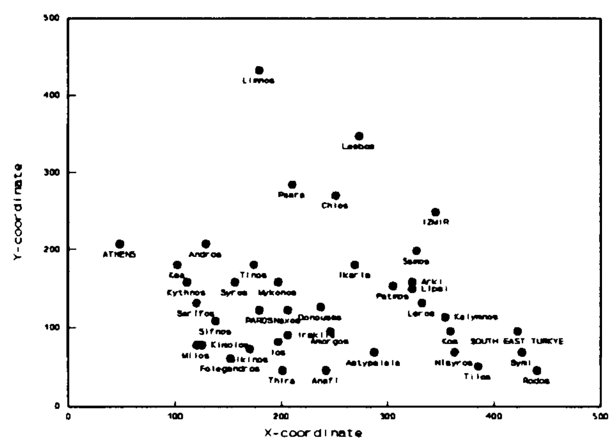


Figure 2: Geographical picture of the nodes in the Aegean

[2] These authors also give an extensive discussion of the entire model and its constituents. For the sake of space limitation these details will not be given here.

The edges in this network are the necessary flows of passengers between the nodes. There are flows between main areas and flows between each main area and a couple of islands. Figure 3 presents a visual overview of the Aegean network. The black arrows represent flows between the main areas. The white arrows represent the flows between the main areas and the islands.

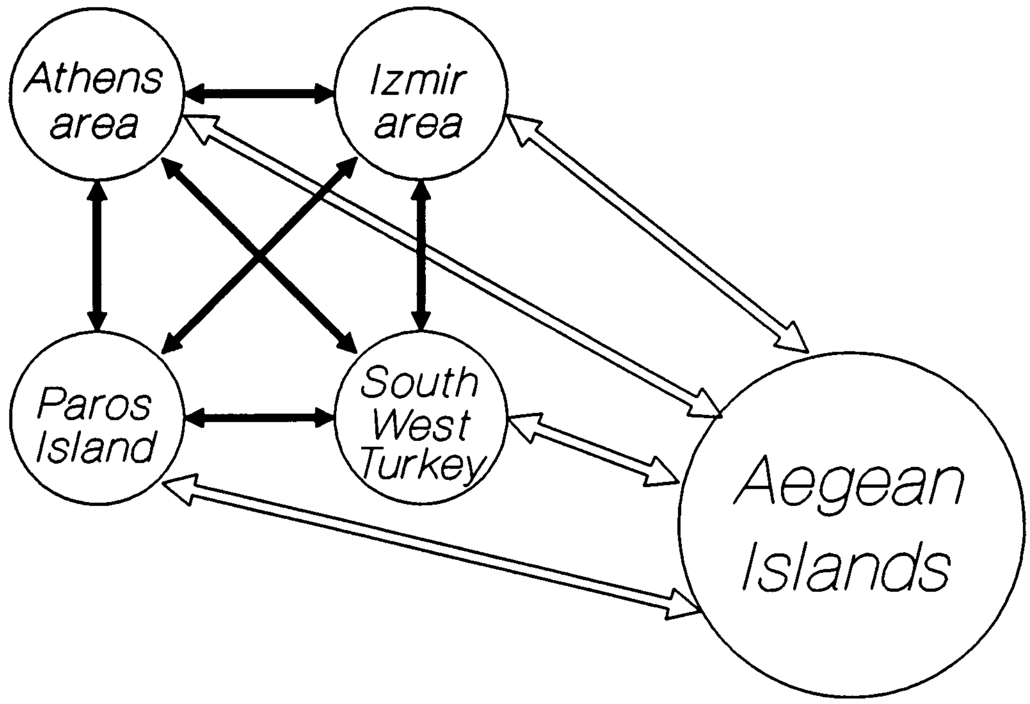


Figure 3: The Aegean passenger shipping network

When a flow exists between one main area (or island) and another one, it means that people wish to depart from a port in that area or on that island in order to go to a port in an other area or on an other island. An island is connected to a main area when there is a flow between these two. A flow from a main area to an island or between two main areas is assumed to be of the same size as its reversed flow. It is only important to know where the passengers originate from and where their destination is. Therefore, this network does not contain a specific flow structure constructed by the supply side. The supply side will be discussed in the next section. It is not necessary to know the exact geographical routes of the ships. Table 2 gives an overview of the characteristics we have selected to portray the network for the **ZKH** model.

- The number of passengers that wishes to depart from a main area to go to another main area or island
- The number of islands connected with each main area
- The distance between each island and main area
- The distances between all main areas
- The ordinal ranking of connection priority of each island
- The connectivity of each island with each main area
- The relative attractivity of each island
- The demand for transport between the main areas
- The demand for transport between each island and main area
- The total demand for transport in the network

- The number of tourist accommodations on each island
- The number of inhabitants on each island
- The tourist image of the Aegean
- The port size of all ports in each main area that handle passenger shipping within the Aegean
- The existence of a political barrier with Turkey
- The geographical coordinates of the main areas
- The geographical coordinates of the islands

Table 2: Network characteristics of the Aegean maritime system

The rank order of connection priority reflects the actual spectrum of choice of people who wish to leave a main area in order to go to various islands. The connectivity deals with the number of main areas the travellers on an island wish to visit. All these characteristics will be translated into variables in the **ZKH** model. For the exact contents of these characteristics including their dimensions we refer to Section 5.

The Greek/Aegean travel pattern clearly shows a seasonal fluctuation. Therefore, we have subdivided a year into two seasons, namely a high and low season, or summer and winter respectively . The high season ranges from April 1st until the end of October. In our application we will start our simulation in the high season of 1993; this is season one. Thus, even seasons are low seasons and odd seasons are high ones. Characteristics cannot change within a season, but can only be changed over seasons.

4. The Supply Side of the Transport Market

The transport line is the set of business firms (companies) that provide passenger shipping transport in the Aegean and thus represent the supply side of the network. The vessels they have can be described by three types of characteristics (see Table 3).

- Technological - Morphological - Origin

Table 3: Vessel and network characteristics

The main **technological** characteristic is the speed level of the vessels. There are two speed levels in our analysis. Speed level 1 indicates the set of slow boats and speed level 2 indicates the set of fast ships. A vessel is fast, when its average speed is higher than 40 km/h.

The morphological characteristic is the passenger capacity level of the vessels. There are two capacity levels. Capacity level 1 indicates small ships and capacity level 2 indicates large ships. A ship is large, when it has a minimal high season capacity of 200 passengers. A vessel with a certain performance is assumed to have only one particular average speed or capacity. We have decided to use these characteristics, in order to be able to analyze the competition between the modern hydrofoils (small and fast) and the traditional ferries (big and slow). The difference in speed level is nowadays approximately a factor 2 and the difference in capacity level is approximately a factor 10.

The origin characteristic is the flag of the ship, representing the country of registration. There are two types of flags: Greek and EU Non-Greek. Ships with a flag of the second type are registered in and owned by nationals of other EU countries. We use this characteristic to analyze the effect of the opening up and liberalisation of the Aegean passenger transport market in the year 2004.

Altogether, we have defined **2x2x2=8** types of ships in the transport line. We assume for the sake of simplicity that every single company has only one type of boat, so that we can analyze the competition between the types of ships by creating eight distinct companies each of which represents a specific company in connection with a corresponding type of vessel. Thus the analysis of different types of ships is the same as the analysis of the competition between the companies. In order to visualize the transport line that consists of eight companies we have put them in a three-dimensional block (see Figure 4). The block has two storeys (flag differentiation), two side wings (capacity differentiation) and a front and back wing (speed differentiation).

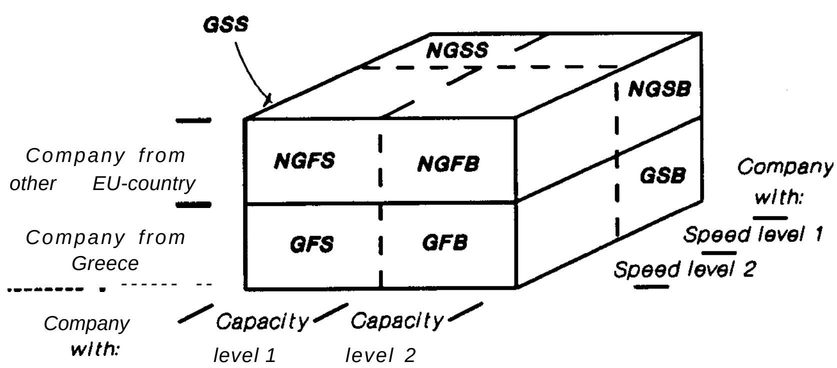


Figure 4: Transport line block

The names of the companies are symbolised by three or four characters. The last character indicates the capacity level of the boats of the company: level 1 is S(mall) and level 2 is B(ig). The one but last character indicates the speed level: level 1 is S(low) and level 2 is F(ast). Finally, the first character(s) indicate(s) the flag of the boat: G(reek) or N(on) G(reek).

The demand for and the supply of transport meets in the transport market. The market is subdivided into only two segments, namely into the segment of companies with ships with speed level 1 (slow boats) and a segment with ships with speed level 2 (fast boats). There is no segmentation into capacity level or flag, because we assume that passengers are not interested in the flag or capacity of the boat they travel with. Their only concern is assumed to be travel time and thus speed. Table 4 gives an overview of the characteristics that we have selected to model the transport line.

- The number of vessels of each company
- The price of each company
- The maximum volume of transport each company can produce
- The price each company asks relative to the other companies
- The relative attractivity of each company
- The average occupancy of the boats of each company
- The profit of each company
- The weighted speed level of all companies together
- The weighted price level of all companies together

- The price for transport set by the government
- The speed of the ships of each company
- The capacity of the ships of each company
- The fixed costs of each company
- The variable costs of each company
- The existence of a cabotage privilege for Greek companies

Table 4: Transport line characteristics

All these characteristics will be translated into variables in the ZKH model. This will be discussed in the next section.

5. The ZKH Model

The ZKH model contains all characteristics described in Sections 3 and 4. The characteristics have been subdivided into two groups. The first group reflects the endogenous variables and the second group reflects the exogenous variables of the model. An endogenous variable is a variable which is determined within the model by other variables. On the other hand, an exogenous variable depends only on variables outside the model or depends only on time. Therefore, the model characteristics can also be split into endogenous and exogenous ones.

Below, we will give an overview of all variables used. The variables denoted with an asterisk (*) are calculated in units of thousand within the model. The ranges of subscripts are $t \in \{1,..., T\}$, $i \in \{1,..., I\}$, $n,m \in \{1,..., N\}$, $k \in \{1,..., K\}$, $s \in \{1,...,S\}$, $c \in \{1,...,C\}$, with T being the number of seasons, N the number of main areas, I the number of islands, K the number of transport companies, S the number of speed levels and C the number of capacity levels. A variable with a subscript k is only used or determined, if the company operates with at least one boat within the transport line.

Endogenous variables (denoted in capitals) are:

$AN_{n,t}$	The number of islands that is connected with a port in main area n in season t
$B_{k,t}$	The number of ships company k has in season t
$CA_{k,t}$	The relative attractivity of a company according to the demand side of the transport market in season t
$D_{n,t}$	The number of people per day that wish to leave a port in main area n to travel to another main area or island in season t (*)
$DI_{n,i,t}$	The demand per day of people that wish to travel from main area n to island i in season t (*)
$DM_{n,m,t}$	The demand per day of people that wish to travel from main area n to main area m in season t (*)
$G_{i,n,t}$	The existence of a connection between main area n and island i in season t
$IA_{i,n,t}$	The relative attractivity of island i according to the demand side of the transport market from the point of view of main area n in season t
$O_{k,t}$	The average occupancy of the ships of company k in season t (full = 100)
$P_{k,t}$:	The price in drachmas per passenger kilometre that a company asks in season t
$PK_{k,t}$	The number of passenger kilometres company k produces per day in season t
PL_t	The price level in drachmas of the transport line in season t
$PR_{k,t}$	The profit per passenger kilometre in drachmas of company k per day in season t
$R_{i,n}$	The ordinal number of an island for connection with a main area n
$RP_{k,t}$	The price of company k relative to the price of the other companies in season t (x 100%)
SL_t	The speed level in kilometres per hour of the transport line in season t
$SM_{n,m}$	The distance between main area n and m
$SN_{n,i}$	The distance between main area n and island i
$TS_{k,t}$	The maximum supply of passenger kilometres per day of company k in season t
TSD_t	The total demand for passenger kilometres per day in season t.

Exogenous variables (denoted in minors) are:

bc_t^c	The passenger capacity of ships with capacity level c in season t
$bcc_{k,t}$	The passenger capacity of ships of company k in season t
bs_s	The average speed of ships with speed level s in kilometres per hour in

season t

$bsc_{k,t}$ The average speed of ships of company k in kilometres per hour in season t

cp_t The existence of a cabotage privilege only for Greek shipping companies in season t

$fc_t^{s,c}$ The fixed costs in drachmas of a ship with speed level s and capacity level c

$fcc_{k,t}$ The fixed costs in drachmas per ship per day of company k in season t

gp_t The basic price for transport per kilometre in drachmas which is set by the government in season t

$gpc_t^{s,c}$ The price in drachmas set by the government for travelling with a ship with speed level s and capacity level c in season t

$ih_{i,t}$ The number of inhabitants on island i in season t

$ps_{n,t}$ The total size of all ports in main area n which handle passenger shipping in the Aegean (in hectares) in season t

$ta_{i,t}$ The number of beds in touristic accommodations on island i in season t (*)

tb_t The existence of a political barrier with Turkey in season t

ti_t The tourist image of the Aegean in season t relative to the high season of 1993 (1993 = 100)

$vcc_{k,t}$ The variable costs per passenger kilometre in drachmas of company k in season t

xi_i The x-coordinate of island i

xn_n The x-coordinate of main area n

yi_i The y-coordinate of island i

yn_n The y-coordinate of main area n.

The relation between the subscripts k and the corresponding companies and the relation between n and the corresponding main areas is given in Table 5.

n	Main area
1	Athens area
2	Paros island
3	Izmir area
4	South-West Turkey

k	Company	k	Company
1	GSS	5	NGSS
2	GSB	6	NGSB
3	GFS	7	NGFS
4	GFB	8	NGFB

Table 5: Subscript relations

The ZKH model contains 20 endogenous variables which are denoted in Figure 5 by ellipses and 15 exogenous variables which are denoted by boxes. The 19 variables concerning the demand side are positioned in the upper segment. These variables have a one-to-one relationship with the characteristics of the network shown in Table 2. The 20 variables concerning the supply side are placed in the lower segment and have a one-to-one relation with the characteristics given in

Table 4. When an arrow leaves and enters the same ellipse, this means that earlier values of a variable are used in the determination of the present value.

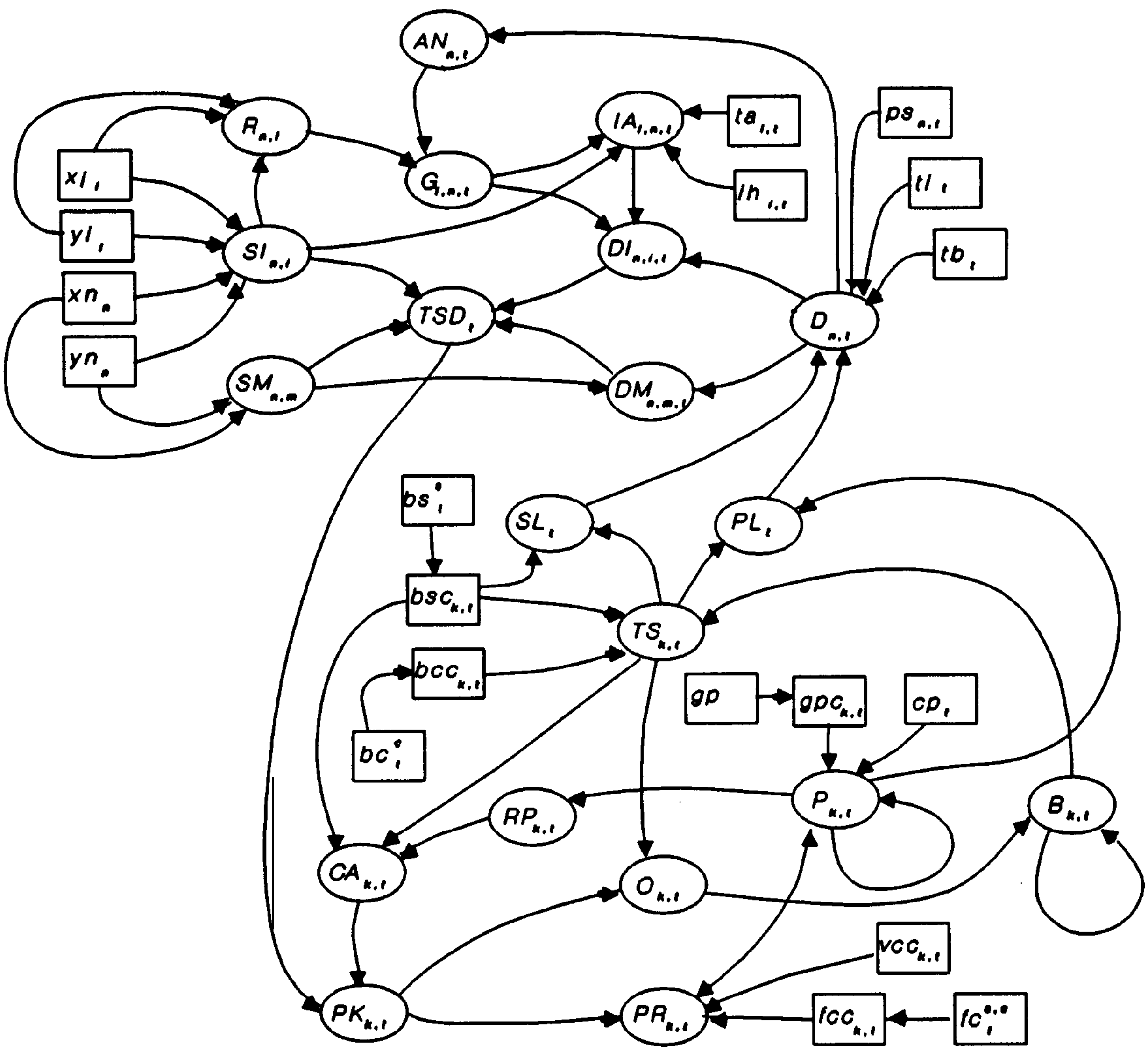


Figure 5: Visualization of the entire ZKH model

A 'walk' through this model structure may offer more insight into the functioning of the model. Let us start at a certain value of the speed level(SL) and the price level(PL) of the system in a certain season. These variables - together with the port sizes(ps), the tourist image of Greece(ti) and the existence of a barrier with Turkey(tb) - determine the demand in the main areas for travelling within the Aegean(D). When we know this demand, we can calculate the number of islands(AN) people wish to travel to. Given this result and using the preference rank order(R) of the islands, we can figure out to which islands they wish to go to(G). The exact flows between the main areas and the islands(DI) are determined by the attractivity of the islands(AI), which depends on the number of tourist accomrnodations(ta) and the number of inhabitants(The flows between the main areas(DN) depend on the demand in both areas(D) and the distance between both areas(SN). On the basis of knowledge of the necessary flows(DI and DN) and the distances(SI and SN), we can calculate the total demand of passenger kilometres per day in the relevant season. This is the result of the first part of the model.

When we know the total result on the demand side, we may next assume that companies will compete in the normal Greek- or more commercialized European-way to get their share(PK), which is determined by the attractivity of each company(CA). The attractivity of a company is set by the kind of ships they have and the price they ask for. When the results, viz. (a) the profit(PR) depending on costs(vcc and fcc) and revenues(PK and P) and (b) the occupancy of the boats(O) depending on maximum and actual supply(TS and PK), are calculated, it is next time to set the price(P) for the subsequent season and to consider (dis-)investments in ships to get an new fleet size(B). The price setting depends on the existence of a cabotage privilege for non-Greek companies. Until the year 2004 the price will be set by the government. When the market becomes free, oligopolistic price policy will come to the fore. With the new prices(P) and fleet sizes(B) for the new season in mind, the price level(PL) and speed level(SL) can be determined and the next season is ready to enter the simulation model.

The next interesting point is the way in which the principal factors are implemented in the model. The development of a hub-and-spokes system corresponds to a growth in port size of Paros($ps_{2,t}$). The development of the relationship with Turkey is built in via the existence of a barrier with Turkey(tb_t) in season t. The technological innovation of the boats is implemented in the development of the speed of boats(bsc) and their fixed costs(fcc). Finally, the unification proces is built in via the realization of the new prices and fleet sizes for each new season. The price and investment policy of the companies determine in what way profits(PR) and prices(P) affect the new prices and in what way the occupancy(O) affects the (dis-)investment in vessels.

In Hiemstra and Zwier (1994) the total model outlined above is split into 24 submodels in order to allow for a detailed analysis of the quantitative and qualitative relationships between the relevant variables. For example, one of the submodels deals with the realization of the flows of passenger demand between the main areas. A gravity model can be used in such cases, where the flow depends on a certain attractivity of the areas (here D) divided by the distances (here S). Thus higher attractivities will cause a higher flow of passenger demand between the areas, whereas on the contrary a longer distance causes a lower flow.

Two submodels which are rather interesting to take a look at are the submodels which realize the new price and fleet size for each company. The price setting is based on several price setting methods in a situation of an oligopolistic market. The methods deal with the price setting of the market leader and the immediate competitors, and the desired profit margin. The information given by the various methods is combined with fixed proportions.

The investment behaviour and consequently the fleet size are based on the average occupancy of the ships in the last couple of seasons (see Figure 6, with the occupancy from prior periods on the x-axis and the investment policy level of the company on the y-axis). The figure is split into areas denoted by a plus or minus number, which indicates the number of ships in which a company should invest. A company chooses a policy level indicated by p^*. If the occupancy of the last high and low two seasons are O_1 and O_2, then these rates should be transferred to the policy line to find out in which area they are. For example, a value of 0, which is in the V-area will generate no investment. On the other hand, if O_2 is in the **'+2'-area,** then the company will invest in two more ships. If $B_{k,t}$ becomes equal to zero, the company is out of business in the transport line.

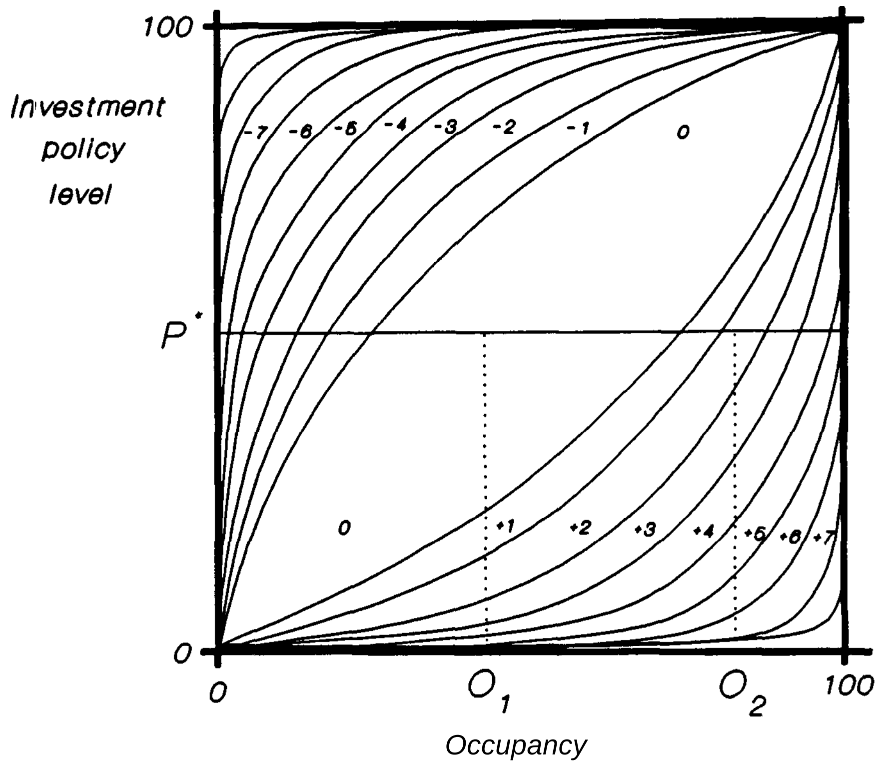


Figure 6: Investment policy level in relation to occupancy

The highest policy level is 100 and a less than full occupancy will cause the immediate withdrawal of ships. The lowest policy level is 0 and will cause an almost continuing investment in new vessels.

We have now discussed some submodels only in a qualitative sense, but without any quantitative representation. All variables are connected with one another in a way which is always open for revision and extension. In the next section some further quantitative results of the model we have built will be presented and analyzed.

6. Results and Analysis

To analyze the principal factors given in Section 2 we will now make use of the input of the ZKH model. The input information is generated by a scenario. A scenario is an abstract representation of the future. A scenario deals with a certain development of exogenous variables over time and with the realization of the price and fleet size in each season. We have created four scenarios and in Subsection 6.1 to 6.6 we will present the development of the variables PL, SL, TSD, D and PK over time under these scenarios. Furthermore, we will also present the results of the variables P, 0, PR and B of the NGFS company over time. In Hiemstra and Zwier (1994) a Decision Support System is presented for easy scenario modification using the ZKH model. By using this software tool a wide variety of results can be generated, but we will stick here only to a presentation of a few interesting results.

The four scenarios are defined as follows. Scenario 1 is a basic scenario. The exogenous variables remain constant over time. All non-Greek companies start with 30 ships in 2004; all companies wish to have the same profit margin of 6 drachmas per passenger kilometre and try to set their price 5% below (underscore) the price of their immediate competitor. All companies have the same efficiency in constructing their lines; boats can operate during an average maximum time span of 12 hours a day. All companies have the same price and investment policy. The barrier with Turkey will remain; no hub-and-spokes system will be developed and no technological development is introduced.

Scenario 2 is equal to scenario 1 with the only modification that the barrier with Turkey will disappear in 2009 and Paros will be developed as a hub-island due to a constant growth of its port size over time.

Scenario 3 is equal to scenario 1 with the modification that the speed of fast ships will go through a constant technological development over time and that the competition between the companies after 2004 will become more intense. This implies that companies are satisfied with a lower profit margin, namely 2 drachmas per passenger kilometre, and that they try to set their price 10% under the price of their competitors. All companies will still adopt the same strategic and investment policy.

Scenario 4 is an extension of scenario 1, as it also incorporates the two previous modifications discussed above.

Subsections 6.1 to 6.6 only show high-season results, because no structural difference between the low and high season was noticed. Only a volume difference could be observed: the price level and speed level are equal in both seasons; the level of demand was 61% lower in the low season, while the demand level in the low season was 41% of its value in the high season. The standard deviation was zero for all four high/low season ratios. The differences in prices set by the companies in both the high and low season did not significantly differ. Greek companies usually asked the same price, whereas non-Greek companies asked a price in the high season which was a little higher than in the low season, namely 2.3%. The occupancy for all companies in the low and high season had a ratio of 65 to 100, while the profit was quite equally distributed. The low season showed a slightly lower result, viz. **96,9%.** No big differences appeared in the fleet sizes in the low and high season, because a temporary low season withdrawal was not modelled.

6.1 Price level development over time

Until the year 2004 the price level development appears to be quite constant. See also Figure 7. Scenario three shows a small increase, because faster ships are coming up and may ask a higher price. When the market is set free, there is an immediate price drop. The fluctuation in the first two years is caused by the behaviour of the companies which try to get a feeling for price setting. Then a more constant decrease of the price appears. The little downward slope in scenario two

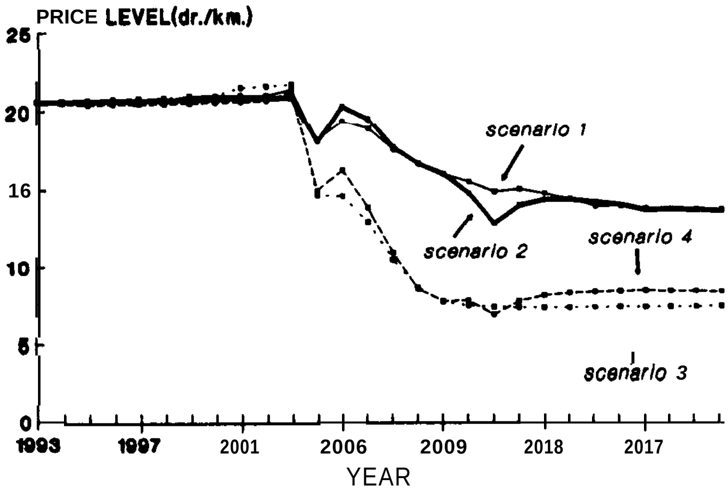


Figure 7: Price level development over time

is caused by the vanishing of the political barrier. Because of a sudden growth of demand, company results are favourable and the price can be set lower to get the desired profit margin, but finally a correction towards the old development is made. The price level in scenario three and four is lower because of the severe competition which was not assumed in scenario one and two.

6.2 Speed level development over time

Until the year 2004 the speed level seems to develop quite constantly, as is shown in Figure 8. The slight increase in scenario three and four is caused by the speed advantage which fast ships apparently have at the demand side of transport market, compared to slow ships. The non-Greek companies will enter the market especially with faster vessels. That is the reason why the speed level shows a quick increase. If the average speed of fast boats is held constant over time, then the market will be fully occupied by these types of boats in the year 2016. An increase in speed as illustrated in scenario three and four will cause the market to be fully occupied by fast ships in the year 2007. The small change in scenario two in 2012 is caused by the political barrier which by then has disappeared, so that an additional demand will apparently cause an extra input of more fast instead of slow ships.

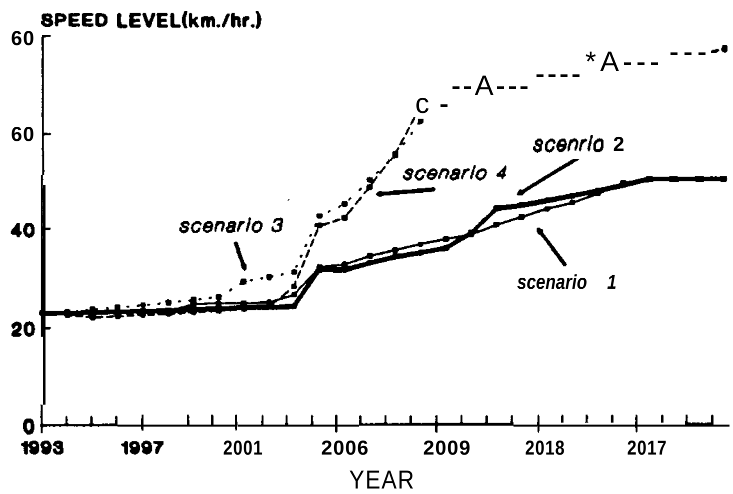


Figure 8: Speed level development over time

6.3 Total daily demand flow development over time

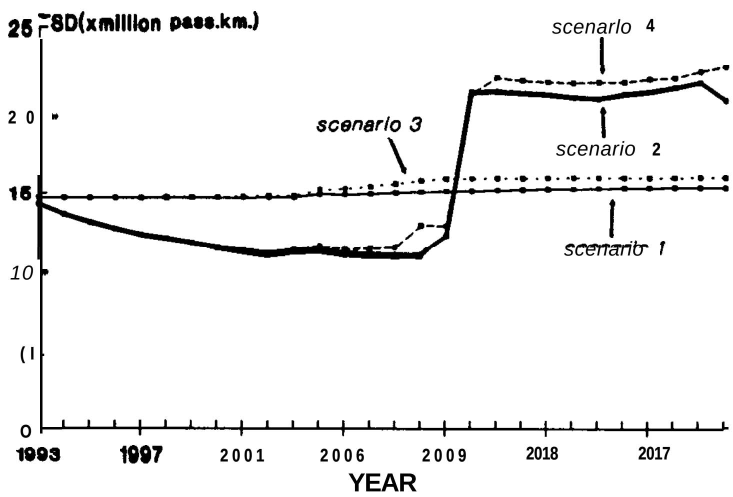


Figure 9: Total demand flow development over time

In the high season of 1993 an average of 15 million passenger kilometres were demanded and produced per day. See Figure 9. It is obvious that under scenario one no big change is expected. Almost everything is held constant. The substantial changes are caused by the hub scenario and the barrier scenario. When Paros will be extensively developed as a hub island, then passengers do not have to travel via Athens anymore to arrive at another island. Travel distances are getting shorter. As can be seen in Figure 9, demand is constant until 2009. Thus, it might be expected that the total demand flow may decrease. The big crack in 2009 is caused by the vanishing of the Turkish political barrier which is implemented in scenario two and four. The daily demand flow does not drop any further because total demand increases.

6.4 Total demand per day

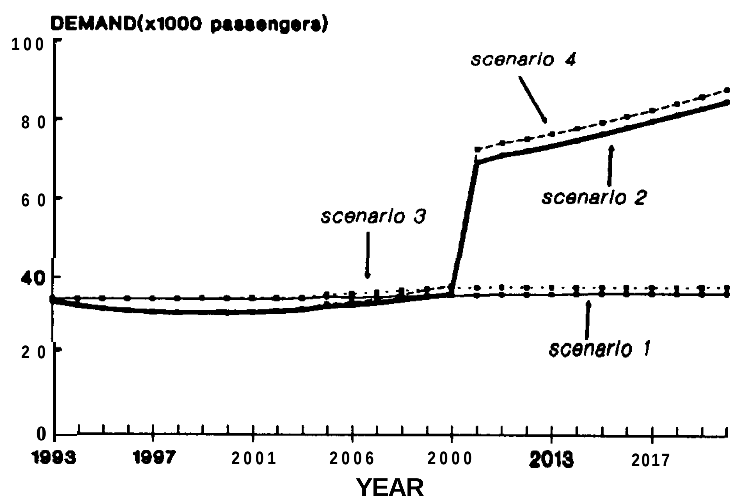


Figure 10: Total demand development over time

It is noteworthy that the development of a hub island will not cause an increase in demand. This is also demonstrated in figure 10. Apparently passengers do care less about travel time. But the combination of the non-existence of a barrier and the existence of a hub will surprisingly cause an increase. This may be caused by the hub, which has a higher performance, when the demand in the eastern side of the network increases. In Figures 11 and 12 the geographical demand development has been depicted. We have visualised six demands, flows, namely TI(the demand between Turkey and the island), PI(the demand between Paros and the islands), AI(the demand between Athens and the islands), PT(the demand between Paros and Turkey), AP(the demand between Athens and Paros) and AT(the demand between Athens and Turkey).

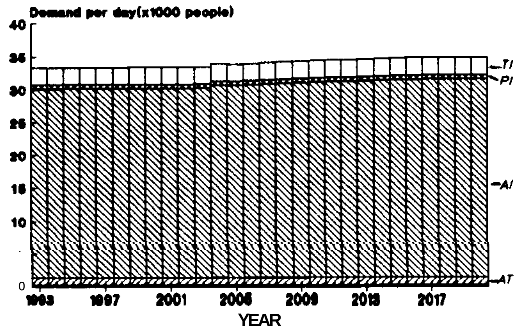


Figure 11: Demand composition of scenario 1

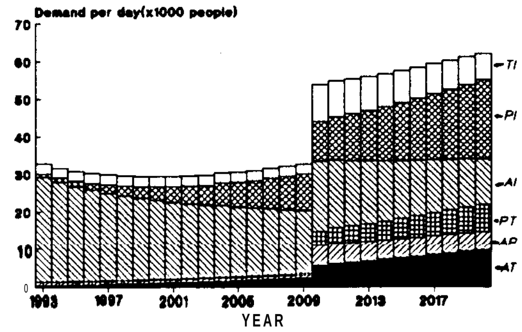


Figure 12: Demand composition of scenario 2

The demand composition of scenario three and four is similar to that of scenario one and two, respectively. As Figure 10 shows, scenario one did not show large total fluctuations. Also, the composition is quite stable. Thus technological development and a change in cabotage privilege appear not to prompt a change in the geographical distribution of demand. On the other hand, the previous discussed combination of scenarios causes - besides a change in volume - also a change in composition. Of course, the demand flow between Turkey and the other nodes show an immediate increase, but as a result the demand between the hub and Athens increases drastically. Although the total demand did not really fluctuate until 2009, the composition shows a certain substitution between Paros and Athens in the demand flow between these nodes and the islands. The constant increase of the total demand, as shown in Figure 10, can now be clarified by looking at their composition.

6.5 Market share

The distribution of passengers is at present quite stable, but with a free market and the technological development coming up, changes in market shares cannot be avoided. The situation in 1995 gives a clear overview of the market share of each company before 2004. The big and slow ships fill the transport line to a large extent. The big fast ships are highly underdeveloped and the hydrofoils (small and fast) have an attractive starting share.

There is much to say about each scenario in the high season in the year after the free market has started (2005) and in the high season of 2015. Therefore, we will first discuss scenario one and review the difference with the other scenarios later.

Scenario one shows a good start for fast and big vessels from non-Greek companies (36%) and a majority market share after 2015 (56%). See also Figure 13. Their Greek competitors have a positive market share development with a smaller growth rate. Although fast vessels seem to conquer the market, small ones seem to face some difficulty in obtaining more market power. The Greek company GFS seems not to be influenced by the free market. Its market share remains constant over time.

It could be expected that slow ships were losing ground. And as can be seen in the year 2015, the only slow ship that still will exist under scenario one in that year are the Greek traditional (big and slow) ferries. But they appear to be moving on their last engines. The fact that time is running out for slow vessels was already clearly shown in 2005 when the Greek big and small ships lost their market share compared to their initial situation. As could be seen before, passengers do not travel more when travel time decreases, but if they have to choose between fast and slow ships, then speed appears to be an important aspect in their decision-making process.

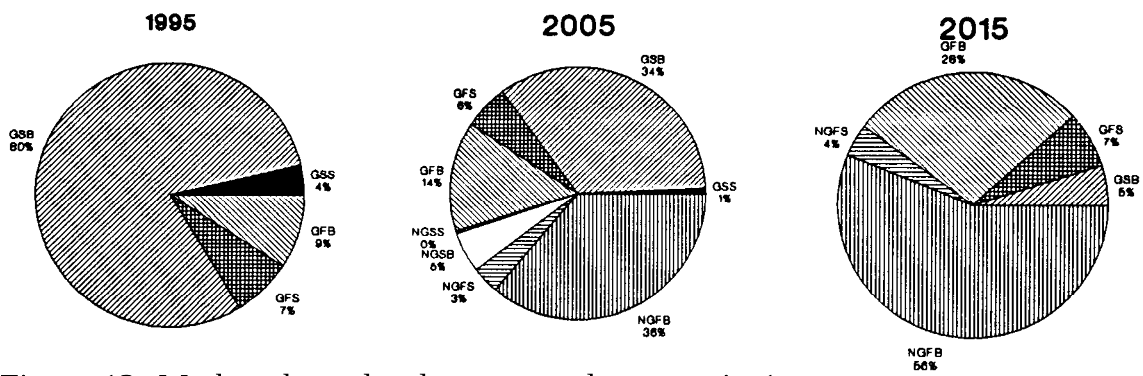


Figure 13: Market share development under scenario 1

Scenario two offers a more modest role for the big fast ships of Greece, as can be seen from Figure 14. This result stems from the hub which causes a decrease in the total demanded passenger kilometres. The NGFB company performs well in that situation. The reason that the GFB market share equals zero in the year 2015 is that we have modelled a no-return clause, once a company reaches zero capacity and is leaving the market. We assume that company NGFB takes over the market share that GFB could have in that case.

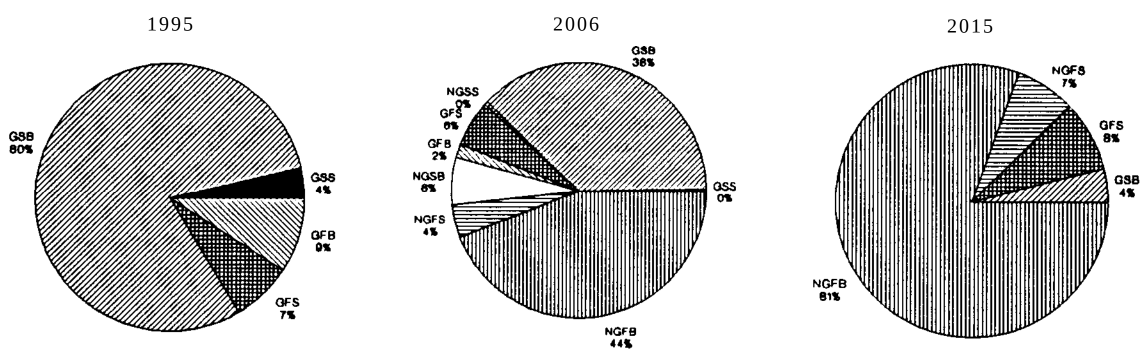


Figure 14: Market share development under scenario 2

Scenario three shows a better emergence for the big fast ships of the NGFB company. See also Figure 15. A tighter competition leaves a 79% market share for companies with fast boats. Especially the Greek company with traditional big and slow boats seems to disinvest extremely: 78% to 18% in 10 years.

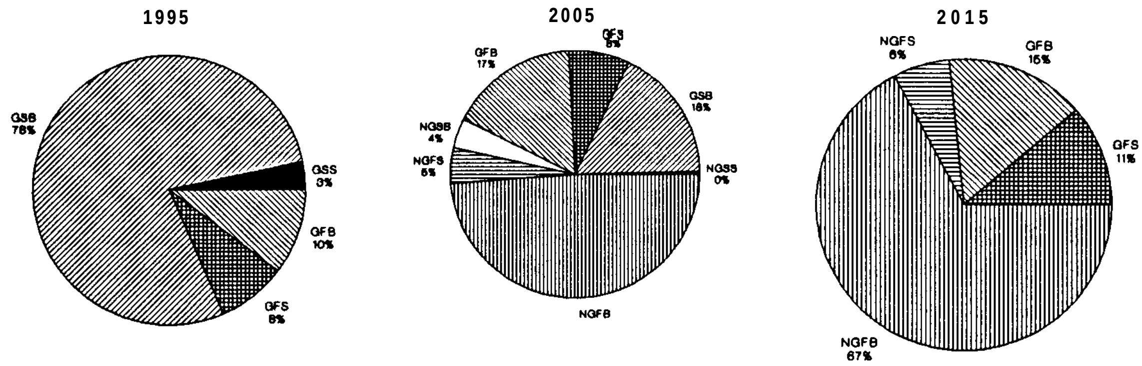


Figure 15: Market share development under scenario 3

Finally, in scenario four an ultimate victory of the non-Greek big fast boats appears in the year 2015. This can be seen in Figure 16. Greek companies have only 9% of the market in their hands. This is alarming for a country with such a strong historical shipping background.

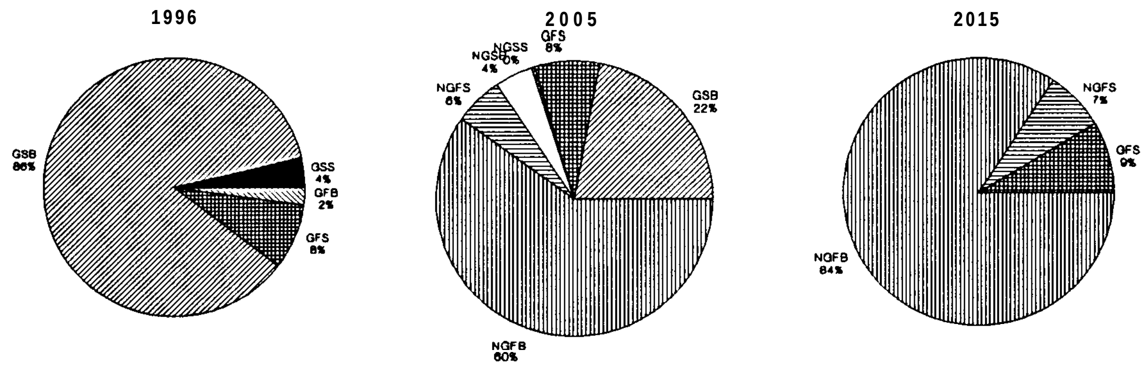


Figure 16: Market share development under scenario 4

6.6 NGFS-company

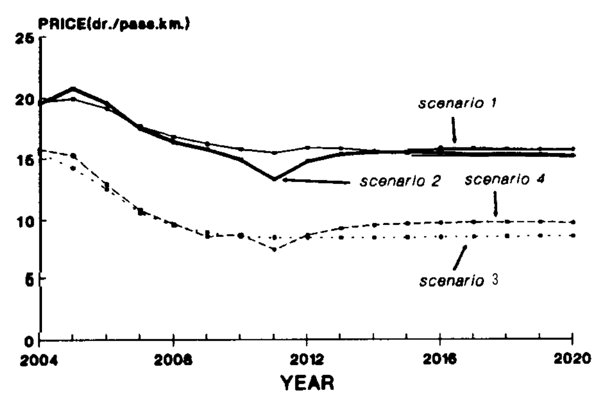
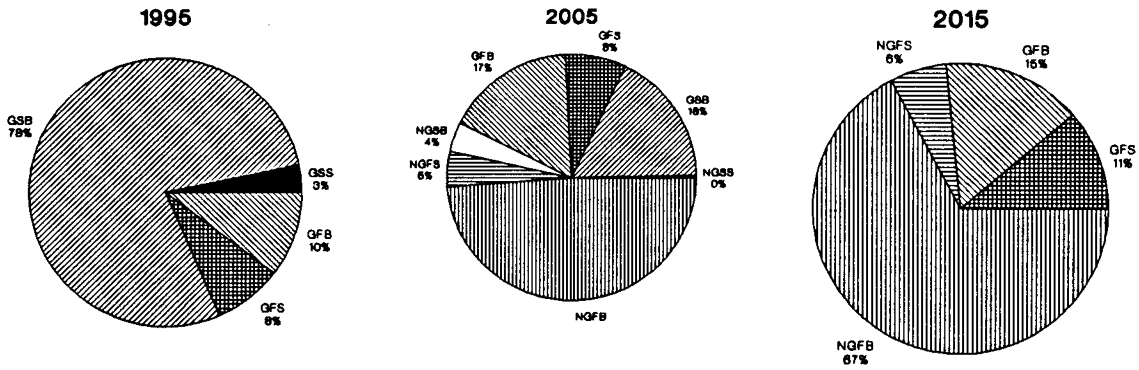


Figure 17: Price development of NGFS

Now, we will look at the results of the NGFS-company. The price, occupancy, profit and fleet size will be compared at the same time. If Figure 7, the price level, is compared with Figure 17, then the price of NGFS has a close correlation. The free market causes a price drop in the first ten years. The slight slope in 2011 can now more clearly be clarified. It has to do with the disappearance of the political barrier. Because of the great demand explosion, the occupancy gets a severe swing, which brings good results to the company, so that a lower price can be set to achieve the needed absolute profit margin.

The difference between the peaks in Figure 18 of the occupancy for scenarios two and four is caused by competition, which leaves a smaller market share for the



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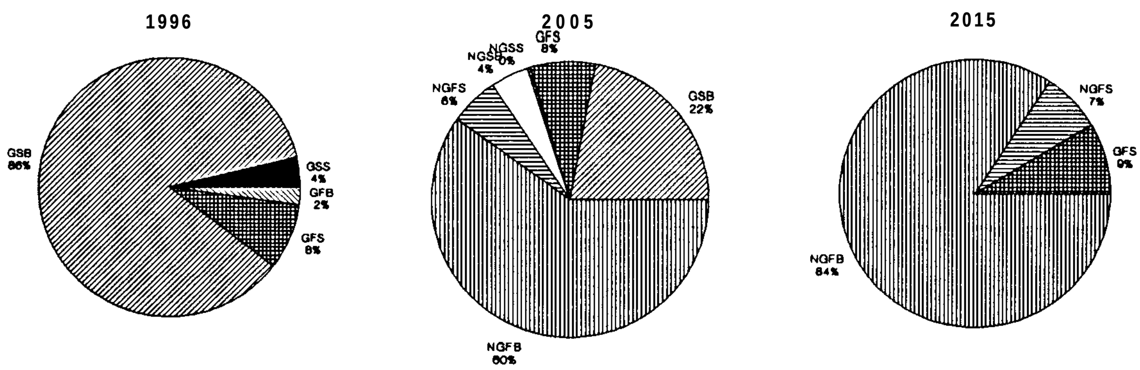
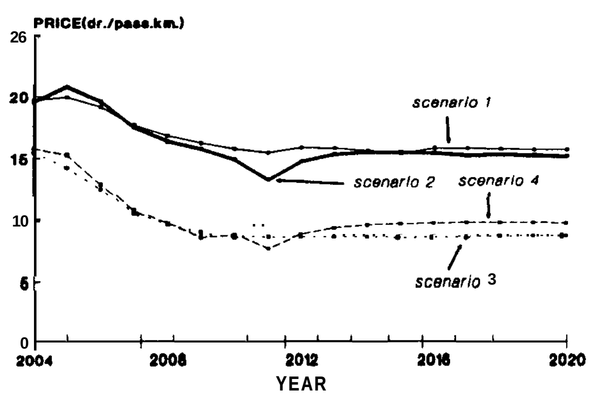


Figure 16: Market share development under scenario 4

6.6 NGFS-company



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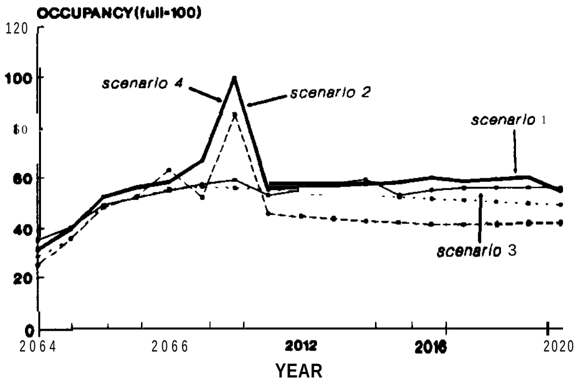

Figure 18: Occupancy development of NGFS

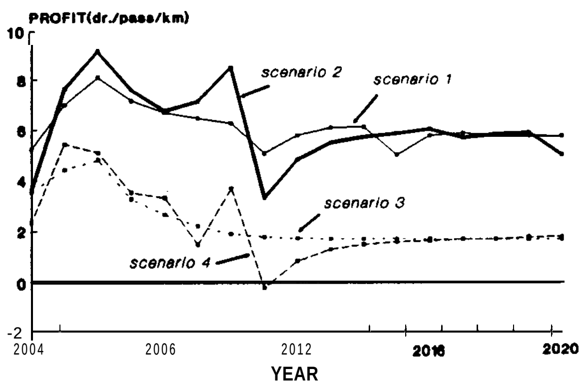

Figure 19: Profit development of NGFS

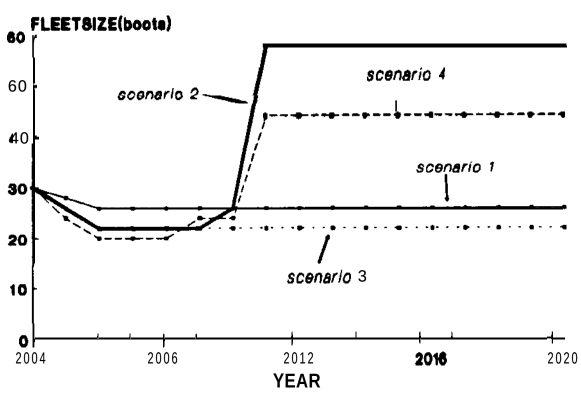

Figure 20: Fleet size development of NGFS

company in scenario four. This difference in occupancy causes the difference in the development of the fleet size under scenario two and four. See Figure 20. The non-barrier advantage can clearly be seen in the higher fleet sizes that occur. The modest drop in the fleet size right after 2004 is caused by an initial input of ships which was too big.

It is interesting to see that the model generates a stable situation in the more distant future. Since however the demand still grows, the extra demand will not be allocated to the companies with small ships but to those with larger ships. The stability is primarily caused by a steady occupancy which induces a non-investment behaviour. A constant fleet size and a stable occupancy appear to produce a stable profit and, because the method of price setting according to the profit margin weighs heavily in the decision-making, the price also shows a balanced development. The influence of this price setting method is substantial. This method incorporated a six drachmas absolute profit margin in scenarios one and two, and a two drachmas profit margin in the scenarios three and four, and nevertheless a convergence appears towards these values six and two. Even if an other price setting scenario would have been chosen, it is plausible that there would be still a convergence, although the equilibrium values would be reached at a somewhat slower pace.

7. CONCLUSIONS

The current Aegean maritime network is strongly regulated by the Greek government. Only Greek businesses are allowed to operate on the network, in accordance with a licence system. Moreover, there is a certain degree of subsidization of routes that are not commercially viable, but that must be served for reasons of accessibility of all inhabited Aegean islands (equity motive). The conventional ferries are still largely serving the market. However, on a number of routes hydrofoils are increasingly being used.

The technological innovations in the shipping sector in the last decade have resulted in increased speed, lower pollution levels and more luxurious and more silent ships. This higher attractivity will have a positive impact on demand for maritime transport. The faster the research into and the technological development of new ships goes, the sooner the traditional ferries will be out of business. The pace of introduction of more comfortable, larger and faster ships should not be underestimated.

The completion of the internal market of the European Union (EU) due to the European unification process implies that from 2004 onwards also non-Greek EU shipping companies are allowed to exploit routes in the Aegean. The cabotage privilege of Greek companies will then be lifted. Competition on profitable lines will increase significantly. Accordingly, the price per passenger kilometre will drop and the quality of service is likely to improve. Shipping companies will try to do their utmost to maintain or even to increase their market share. Therefore, they have the possibility to differentiate themselves from their competitors, by price and service. Greek companies will have to show a more commercial attitude in serving the (free) market; otherwise non-Greek companies will benefit from the lack of the use of marketing techniques of Greek companies. More attention for passenger needs will guarantee or even strengthen market shares of the companies at hand. The level of competition will be Damocles' sword above the heads of the weakest companies. Although there will be an unbalanced market in the year after 2004, we predict a stabilization of market shares in the long run.

If the political relations of Greece with Turkey improve, the economic relation is also likely to ameliorate. Additionally, numerous forms of travel restrictions will be relieved. This will lead to an increase in Greek-Turkish traffic, favouring the transport sector. This will also shift the spatial distribution of demand for transport in the Aegean. The centre of gravity of the network will probably gradually move eastward and a more centrally situated hub island will be more viable and yield significant network efficiency gains.

One of the possibilities in the hands of the network actors and operators to improve the attractivity of the network is to design a hub-and-spokes type of network with Paros as a potential hub. This type of networks bears a larger degree of connection density and accordingly a shorter average travel time. This is especially beneficial to the transport users due to the supply of a more attractive service. The transport line has to face a loss in the production of passenger kilometres, but the generated efficiency gains will increase demand.

The model sketched above appeared to yield a plausible description of the Aegean transport market. It also has a sizeable set of extension possibilities. We will discuss here only a few. A first model improvement can be found in the direction of statistical analysis by investigating the probability of appearance of various scenarios. Second, the improvement of the relationships between the variables may be realized by undertaking a more comprehensive causal analysis. Third, it is interesting to consider also air transport, the service quality, the structure of the transport lines and more price differentiation and market segmentation. Finally, the model would become more realistic by using proper econometric methods and by undertaking data analysis to identify more proper values of the parameters. In the present version of the model we have used the method of calibration and 'questination' because of missing data in order to get plausible parameters.

References

Biehl, D., **Infrastructure and Regional Development,** EC, Brussels, 1986

Bruinsma, F.R. **,De Invloed van Transportinfrastructuur,** Nederlandse **Geografische** Studies, No. 175, Amsterdam, 1994

Capello, R., **Telecommunication and Regional Development,** Avebury, Aldershot, UK, 1994

Cuadrado-Roura, J.R., P. Nijkamp and P. Salva **(eds.), Moving Frontiers,** Avebury, Aldershot, UK, 1994

ECMT, **Short Sea Shipping,** Paris, 1993

Goulielmos, A.M.,and M. Lekakos, The economic structure of Greek passenger coastal shipping, in: **Proceedings of the First European Research Roundtable Conference on Shortsea Shipping,** Technical University Delft, Lloyd'sof London Press Ltd., 1992, **pp.301-315**

Gwilliam, K.M.(ed.), Current **Issues Maritime Economics,** Kluwer, Dordrecht, 1993

Hiemstra F. and R. Zwier, **Passenger Shipping System in the Aegean,** Master's Thesis, Dept. of Economics and Econometrics, Free University, Amsterdam, 1994

Jacobsen, U. and J. Kristiansen, Transport networks for peripheral regions, in: **Transportation research,** 1992, pp. 198-210

Lloyd's List International, "Greece" and "Champion of the cabotage", London, 1991, **pp.8-46**

Nijkamp, P. **(ed.), New Borders and Old Barriers** in **Spatial Development,** Avebury, Aldershot, UK, 1994

Nijkamp, P., S. **Reichman** and S. Wegener **(eds.), Euromobile,** Gower, Aldershot, UK, 1990

Nijkamp, P. and J. Vleugel, **Missing Transport Networks** in **Europe,** Avebury, Aldershot, UK, 1994

Porter, M.E., **The Competitive Advantage of Nations,** Free Press, Boston, 1990

Psaraftis, H.N., **Prospects for the conventional passenger/car ferry in the Aegean,** paper presented at Conference "Overcoming isolation", Plomari, **Lesbos,** Greece, 1993

Psaraftis, H.N. and A.D. Papanikolaou, Impact of new technologies on **shortsea** shipping in Greece, National Technical University of Athens, paper presented at **First European Research**

Roundtable Conference on Shortsea Shipping, TU Delft, The Netherlands, 1992

Wijnolst, N., C. Peeters and P. Liebman(ed.), European Short Sea Shipping, Lloyd'sof London Press, 1993